Designing a Method for Determining Cyclic Delamination Rates in Fiber Backed Fluoropolymer Linings

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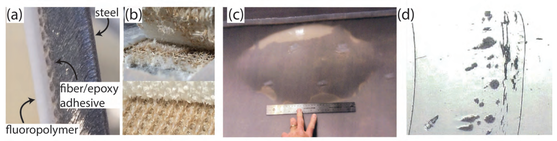
Why do we care about fluoropolymer liners?

- Polymer liners are all around us, metal containers are easily corroded and need protection.
- Fluoropolymers like Teflon™ are nonstick and corrosion resistant.
- How can a nonstick material be adhered to a steel tank surface?

What can cause delamination?

- **The problem:**
  Fisher Company was observing failure from 'blister' type delamination flaws in their lining materials.

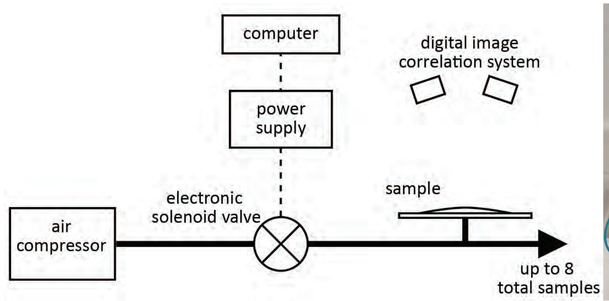


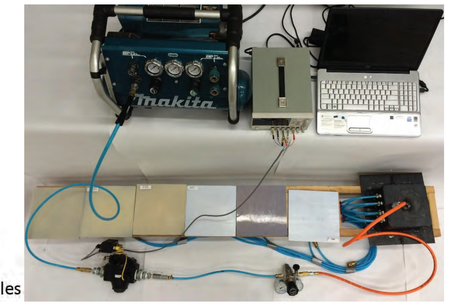
- **Vacuum:**
  1 atm ~15 psi, or 395 lbs acting on a 6" delamination.

- **Thermal Stresses:**
  Hot sulfuric acid loaded into trailers during winter.

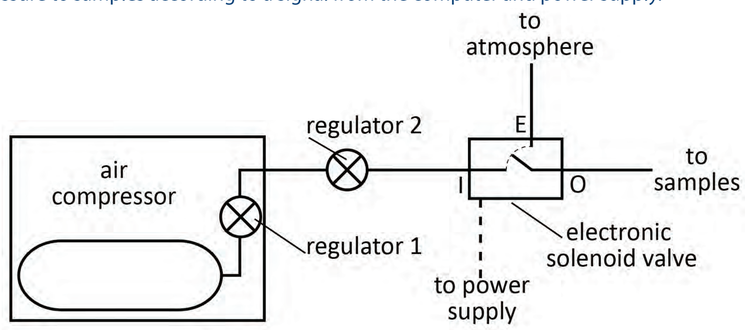
A system design for achieving a full predictive failure model

- The design solution consists of three main systems. The computer and power supply make up the automated control system, the air compressor and associated fittings supply pressure, and measurement data is taken by a digital image correlation (DIC) system as a function of cycle.

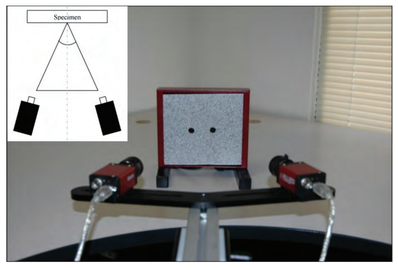


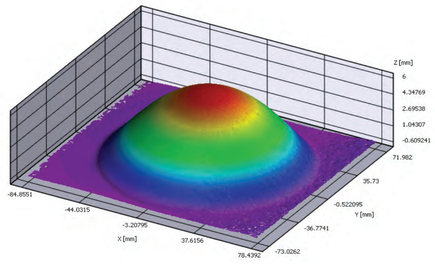


- **Automatic pressure cycling system:**
  - The system pressure is supplied by an air compressor and a series of regulators. An electronic solenoid valve applies pressure to samples according to a signal from the computer and power supply.



- **Digital image correlation (DIC) measurement system:**
  - Driving force for blister growth is determined plotting cycle pressure against blister volume and taking the difference in the area under the curve with each cycle.
  - DIC uses two cameras to produce an accurate 3D map of a surface much like person sees depth using signals from both eyes.



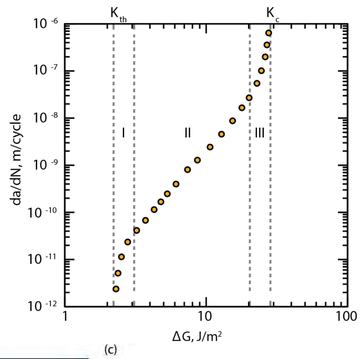


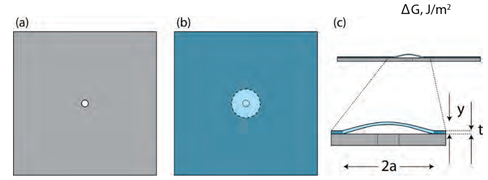
How can we test/describe fatigue in coatings?

- Paris Law describes flaw growth and fracture.

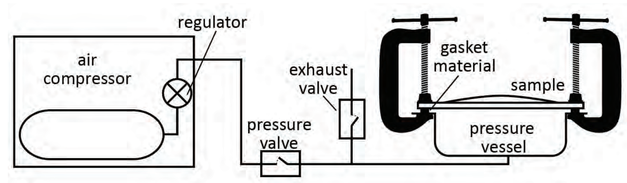
$$\frac{da}{dN} = A(\Delta G)^n$$

$\frac{da}{dN}$ - flaw growth rate
A, n - crack growth constants
ΔG - energy release rate

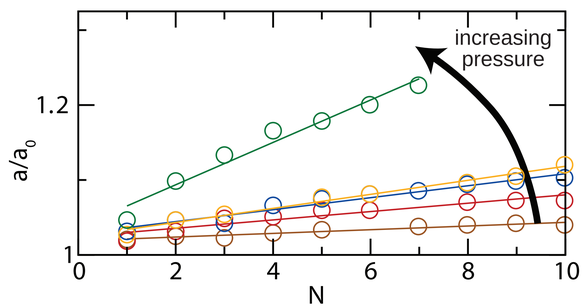




- Samples with an initial delamination zone were pressurized from holes in the backing plate to simulate vacuum.



- Normalized half crack length, a/a_0 against number of cycles for increasing cycle pressure.



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